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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

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THIS ISSUE

Pressure

The Problems of Lubrication Presented by Higher Operating Pressures

PUBLISHED MONTHLY BY
THE TEXAS COMPANY
TEXACO PETROLEUM PRODUCTS

VCA

Lubrication under High Pressures

IN TYPES of machinery where high pressures are inherent to operating conditions, the maintenance of effective lubrication is a problem on whose solution depends the life and efficiency of the equipment involved.

Effective lubrication presupposes the maintenance of a film of lubricant—despite the action of the pressure in forcing the lubricant out of the bearings.

Two avenues of approach are available: Either to bring the lubricant to the point of pressure by means of properly designed lubricating equipment, or, where that is impractical, to select a lubricant with suitable adhesiveness and adequate viscosity to remain on the bearing surfaces in sufficient quantity to reduce wear.

The principles of application and selection are discussed in our article in a general way, with specific references to the more outstanding operations in some of the major industries.

Naturally, a treatise of this size and scope cannot cover or even touch on every operating condition likely to be encountered.

However, we invite all those who desire further discussion of their individual problems to address us.

From the vast reservoir of their experience, Texaco Engineers will transmit to you the exact recommendation for a specific lubricant to provide in each case effective and economical lubrication.

Your inquiries are cordially invited.

We shall be glad of the opportunity to assist all of those engaged in the use, study or purchase of lubricants.

THE TEXAS COMPANY

Texaco Petroleum Products

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Pressure

The Problems of Lubrication Presented by Higher Operating Pressures

THERE are certain basic factors in the operation of mechanical equipment which may frequently give rise to problems in lubrication of bearings, gears and other frictional elements. As a general rule these will involve the operating pressures, the prevailing speeds, and the temperatures to which the parts may be exposed.

The extent to which any or all may affect the accomplishment of lubrication and the ultimate efficiency of machinery will, of course, depend upon the intricacy of construction, the intensity of operation and the duty required of the equipment.

As a result, careful study of every detail is essential. Especially will this be true where production is extensive and where machine operation is co-related. In such cases failure of any particular unit by reason of the faulty lubrication of any of its wearing elements might easily result in production schedules being affected, and plant output as a whole slowed down.

It must be remembered that in very many industries there will be lack of standby equipment. Therefore, if any piece of machinery must be cut out for repair, its work must either be done by frequently make-shift methods, or, where practicable, eliminated from the schedule.

Pressure a Distinct Factor

Where operating pressures between wearing elements may be relatively high, the possibility of abnormal wear due to impairment of lubrication must always be considered. In many plants the machinery where such pressures may prevail will be comparatively massive and designed for heavy duty.

Typical examples will be rolling equipment in the steel mill, the metal press in the automotive plant, the cement kiln and the news or textile press, or the milling machine.

In virtually any piece of machinery where pressure may prevail it is important to remember that it is the "operating pressure" which must be considered. When the rolling mill or metal press, for example, is idling, the pressure which may exist between the teeth of its gear trains, or upon the bearings of certain of its shafting may not be abnormal. When idling there should, therefore, be no problem in the maintenance of lubrication on such equipment.

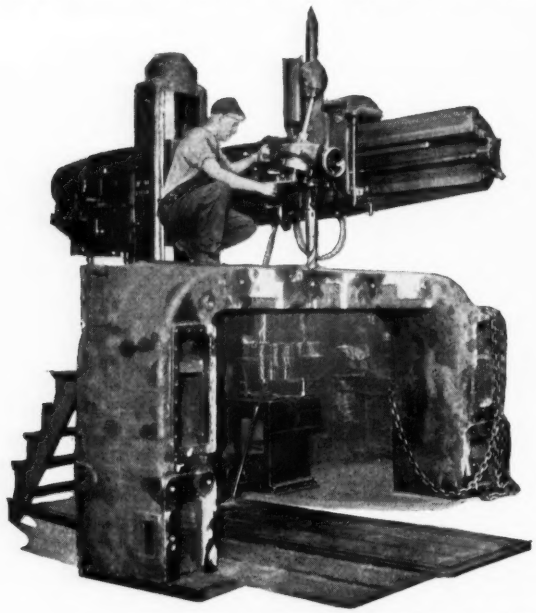
When under operation, however, the pressure to be exerted upon the raw materials in the formation of finished or semi-finished products will react back through practically all the moving elements of the machine. Not with the same intensity in every case, to be sure, for this will depend upon the size or relative importance of the parts involved. But, in general, such reactionary or back pressures will be considerably in excess of the idling pressures, and hence they will be a potential cause of lubricating difficulties.

Operating Pressure the Criterion

As a result, it is the operating pressure which must be taken into account when selecting

lubricants for any particular type of heavy duty machinery, or its respective wearing elements.

The purpose, of course, must be to use lubricants which will be of such body and adhesive



Courtesy of Niles-Bement-Pond Co.

Fig. 1—The boring machine is a typical instance of heavy duty equipment wherein high operating pressures may prevail on the various wearing elements. In view of the fineness of construction, abnormal wear of bearings for example, might materially affect the subsequent accuracy of cutting if lubrication is impaired.

ability as to effectively withstand being squeezed out from between gear teeth, chain link connections, or bearings and shafting. These characteristics in the lubricants must be considered from the viewpoint of maximum pressure involved.

Of course, on certain machinery this may result in abnormal internal friction within some lubricants when the machinery may be idling, but it is far more important to prevent metal-to-metal contact under high operating pressures and thereby preclude the development of abnormal wear, than to reduce power consumption during idling. This is especially true inasmuch as such machinery to develop maximum efficiency should idle as little as possible.

Viscosity the Salient Characteristic

The effect of pressure upon the viscosity of lubricants has been studied in detail by Hersey and Shore* and their paper on this pertinent topic as presented before the American Society of Mechanical Engineers is noteworthy for its developments. It stresses the desirability of—"knowledge of the viscosity of oils up to a moderately high pressure"—especially for metal-drawing processes and hydraulic press operation, etc.

So a consideration of viscosity as a factor in the selection of lubricants for service under high operating pressures will be of interest.

Viscosity being a measure of the relative fluidity of a lubricant is indicative of the body of the latter. Practically speaking, this means its ability to withstand the squeezing out effects of pressure by virtue of the cohesion between its component molecules.

Space Limitations Important

Of course, Hersey and Shore treat with pressure as applied to lubricants within a space of definite limitations. Rarely will such conditions hold true in actual operation, for it is practically impossible to build the lubricating system so tight in the average heavy duty machine.

It is reasonable to presume, however, that in oil-tight bearings these conditions of test will be perhaps simulated to a certain extent; in other words, the lubricant will be subjected to mechanical pressure at a rate exceeding its ability to leak or pass from the bearing. Under such conditions their statement that—"the effects of high pressure are presumably similar to those caused by cooling to a low temperature at atmospheric pressure"—will be true in actual operation. In other words, it will mean that the relative fluidity and sluggishness of the oil may be markedly increased.

This should promote effective lubrication unless it occurs to an extreme, for the existing oil film will be compressed and rendered more capable of preventing metal-to-metal contact. But, of course, lack of adequate fluidity must not result, for this might mean that certain parts of the bearings would be receiving practically no oil. Especially would this be true in self-contained circulating lubricating systems.

On most machinery, however, which will be subject to heavy bearing or gear tooth pressures, the lubricating film will have some place to go. In other words, whereas high mechanical pressure may be involved, the lubricant will still be exposed to atmospheric pressure at the ends of bearings or sides of gear teeth.

In consequence, the extent to which it will continuously maintain a lubricating film of adequate thickness will depend upon its ability to resist being squeezed out, as already stated.

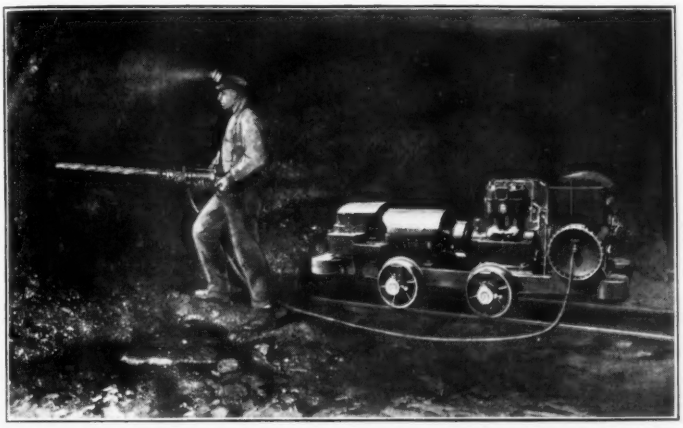
Viscosity Defined

Viscosity has been defined in connection with other articles in LUBRICATION. It is fitting, however, to repeat at least an explanation of the manner in which it is customarily measured and specified when it is to be used as a guide to the lubricating ability of an oil.

*"Viscosity of Lubricants Under Pressure" by Mayo D. Hersey and Henry Shore. Presented at the Annual Meeting of The American Society of Mechanical Engineers, Dec. 1927.

A typical instance would be that a product for the lubrication of the gears of a rolling mill should have a viscosity of say 2,000 seconds Saybolt at 210 degrees F.

This would mean that when tested by the Saybolt Universal Viscosimeter, 2,000 seconds would be required for 60 cubic centimeters of the lubricant to pass through the instrument at 210 degrees F. In other words, viscosity constitutes the observation of the number of seconds required for a definite volume of oil to pass through a standardized orifice at a definitely controlled temperature.



Courtesy of Ingersoll-Rand Co.

Fig. 2—In the mining industry, the rock or coal drill is a most important piece of equipment. Frequently the hardness of the product being cut will impose severe back pressures on the working elements of the drill. Hence, the necessity for careful lubrication, commensurate also with the operating temperatures.

Stated as above it means but little to the average layman. With a knowledge of the comparative fluidity, however, a viscosity specification is readily understood and can be interpreted accordingly. This has been discussed more in detail in the December, 1927 issue of LUBRICATION.

Operating Temperature Must Also Be Considered

It is important to remember that viscosity varies inversely with temperature. In other words, the higher the latter the more fluid will be the lubricant. This premise holds true for many other fluids as well, viz.: the comparative fluidity of molasses in summer and winter.

Of course, there is a tie-up in this regard when lubricants are to be chosen for high pressure service. Where operating temperatures are high, as in the steel mill, the "operating viscosity" will be proportionately lower. So it is not safe to assume that a lubricant which would function effectively on the gears of a metal press exposed to relatively low shop temperatures in winter time, would, at the same season of the year, also serve the gears of a steel rolling mill. The radiated heat from the red hot ingots, bars or billets might easily render such a lubricant altogether too fluid.

Determination of the "Right" Viscosity

It is difficult to arbitrarily state that for certain parts of a certain type of equipment a lubricant of a certain viscosity should be used. Operating conditions will vary too widely as a rule. This will hold true even though bearing and gear tooth pressures in pounds per square inch are actually known. Speed of operation, the means provided for lubrication, the prevailing operating temperatures, and the extent to which the wearing elements are exposed, must all be considered.

TYPES OF PRESSURE EMPLOYED IN INDUSTRY

In the application of pressure to materials for the purpose of producing finished or semi-finished products the basic principle of operation will involve either rolling or direct pressing.

In the former, materials may be either worked down from larger size, as occurs in the rolling of steel; or, the purpose of pressure may be to finish or imprint certain designs upon the product. The calender roll in the textile mill, and the news press are examples of the latter.

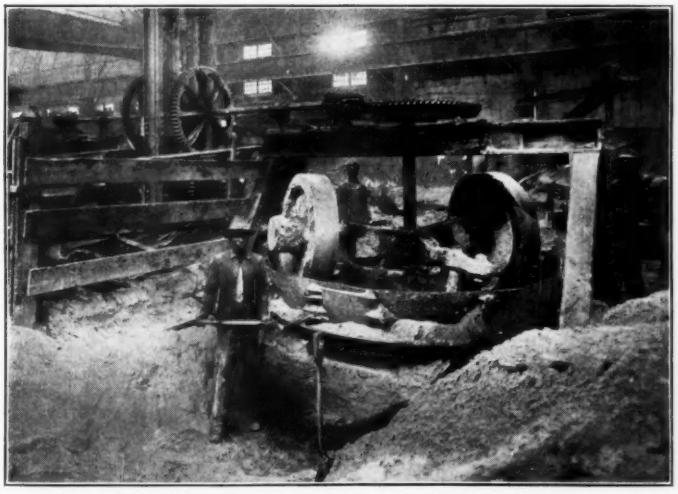
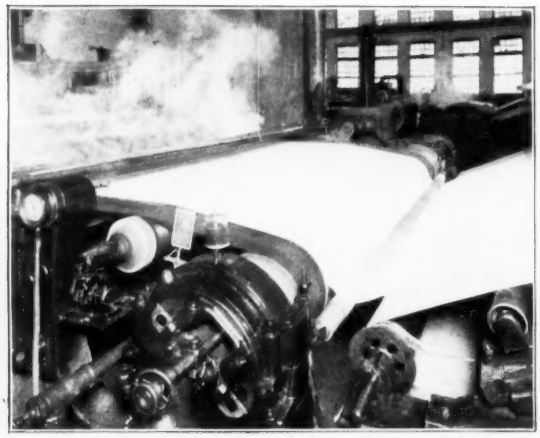


Fig. 3—Grinding of clay products is another phase of industry wherein pressure may react to a considerable extent upon gear teeth and bearings. Note in addition, that gears are exposed to dust and dirt in this particular instance.

Direct pressing in turn is extensively involved in the manufacture of metal plate products for household purposes, in the formation of cans and in the manufacture of automobile body parts.



Courtesy of The Champion Coated Paper Co.

Fig. 4—A paper mill suction couch roll showing the means provided for bearing lubrication.

ROLLING PRESSURE EQUIPMENT

Where rolling pressure is involved, heat will also very frequently be employed. The textile calender roll and the dry end of the paper machine are notable examples of this. Steam will in general be used for this purpose, the rolls being hollow and equipped with cored out journals or roll necks to permit of the necessary circulation.

The bearings which carry these latter will receive more or less heat from this steam, especially on the inlet side. Cooling by water circulation is, of course, practicable, but in many instances the bearing temperatures will be decidedly high, notwithstanding.

In addition to this problem of heat the unit pressure per square inch on such bearings will be comparatively high.

The Paper Machine

The details of lubrication as employed for the press and dryer rolls of a paper machine will be of decided interest in this regard.

To many this stage of operation in the production of paper is probably the most marvelous, for it involves the actual conversion of the mushy fibrous web into real paper. The entire process involves treatment by rolling under high pressure and temperature. Pressure is developed on certain machines by an arrangement of weights and levers. Preliminary drying is thereby effectively brought about, in many instances the resultant web of paper being as much as 35% dry.

The pressures developed in the operation of such equipment of course will be reacted upon the journal bearings. As a result, the lubricants used must not only be of adequate body or viscosity to withstand being squeezed out, but also the means of lubrication must be positive and preferably automatic, for this will better insure the maintenance of the requisite film of lubricant.

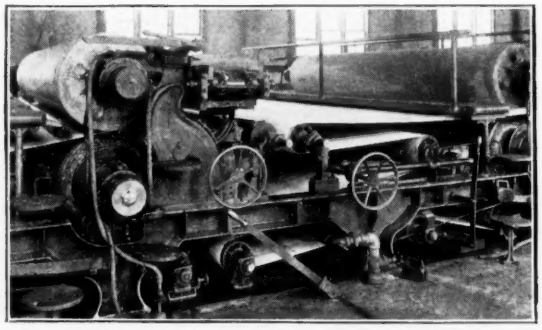
The real problem, however, will be met where high pressure and temperature are involved, as in the operation of drying machinery.

Paper as it leaves the press rolls will still contain about 60% water. It must, therefore, be passed over and under an extensive series of "dryers" to complete the dehydration process. The application of steam for this purpose, and the general construction of the rolls has already been referred to above. The number involved will be extensive, frequently as many as 100 being employed. In general, they will be gear driven and designed to operate synchronously.

Lubrication Details

Dryer bearings offer one of the most difficult lubrication problems in the paper mill due to the high temperatures and pressures employed. Operating speeds, however, are comparatively low. The bearings of the rear or steam side journals are frequently inaccessible due to the driving gears, therefore some form of automatic lubrication is a necessity to insure positive operation at all times.

When such bearings are of the plain sleeve variety, they may be provided with a grease pocket, or a recess for oil. In those of the latter type, wick feed oilers, or a combination wick and pad type lubricator will frequently be very dependable.



Courtesy of Beloit Iron Works

Fig. 5—The press rolls in a paper mill showing water cooling hose for bearings. The use of cooling water will generally require attention to the non-emulsifying characteristics of the lubricants involved, as well as to viscosity in the interests of resistance to the squeezing out action of pressure.

Neglect of these bearings may soon cause the dryers to sag down at the back, and if allowed to continue, unnecessarily high repair costs may result. The steam joint can also be very advantageously equipped with wick oilers

which will furnish automatic lubrication for a week or more at a time.

Ring or collar oilers are also adaptable for such bearings. The anti-friction bearing is, however, the most outstanding development in more recently installed dryers.

Where ring or collar oilers are employed they may often be used in conjunction with continuous oil stream and filtering systems. This not only keeps the oil clean, fresh and cool, but also assures a positive supply of oil, even if the system should break down, owing to the fact that the bearing housings serve as small reservoirs with a sufficient oil bath for several hours.

In general, it is desirable to use an oil of comparatively high viscosity to withstand the high pressures involved. Yet it must be fluid enough to spread readily over the bearing surfaces. Furthermore, it must not tend to vaporize when exposed to higher temperatures as a thin film on the journal. As a rule, the lower viscosity limit on close fitting bearings equipped with automatic oiling devices will be approximately 60 seconds Saybolt at 210 degrees F. For worn or loose bearings, however, even as high a viscosity as 170 seconds Saybolt at 210 degrees F. may be advisable.

When dryer bearings are to be lubricated with grease a special high melting point product should be used which will show no tendency to separate, cake or develop free acidity.

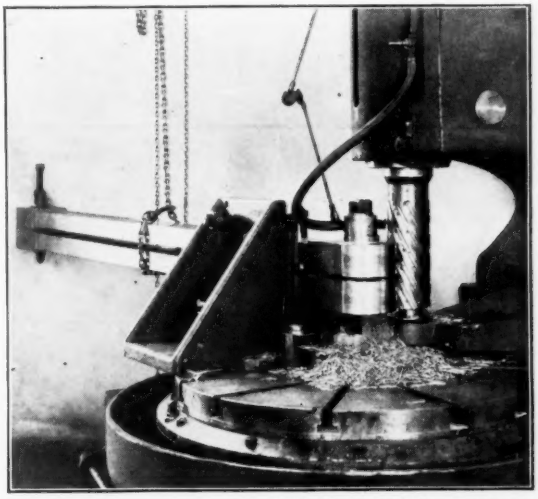
Textile Printing Machinery

The essential problem that is usually met with in the lubrication of a rotary textile printing machine involves the mandrel bearings of the engraved printing rollers. Pressures exerted upon these bearings are normally high; i.e., in the neighborhood of 700 to 800 lbs. per square inch, and the difficulty is to obtain a lubricant that will have sufficient viscosity to resist being squeezed entirely out from between the roll necks and the bearings, and that will insure as low operating temperatures as possible.

The bearings for such rolls are frequently built of split bronze sections, for example, with no oilways cut in their surface. Thus the only means by which the lubricant can work its way between the wearing surfaces is along the chamfered edges of the bearings. Although the operating speed of such machines is relatively low, and 50 to 60 yards of fabric per minute is the average production, it is often difficult to keep the temperature of the mandrel neck and bearings comfortable to the touch, and frequently they will run so hot as to cause smoking or even flashing of the bearing lubricant, especially when the pressure screws are set up to their tightest.

Means of Lubrication

There are normally no means installed for the mechanical lubrication of such bearings, and general custom is to lay an oil or grease soaked pad of some form or other onto the rolls.



Courtesy of The Ingersoll Milling Machine Co.

Fig. 6—Showing the essential features of a milling machine cut, and the necessity for proper lubrication of wearing elements due to the pressures involved.

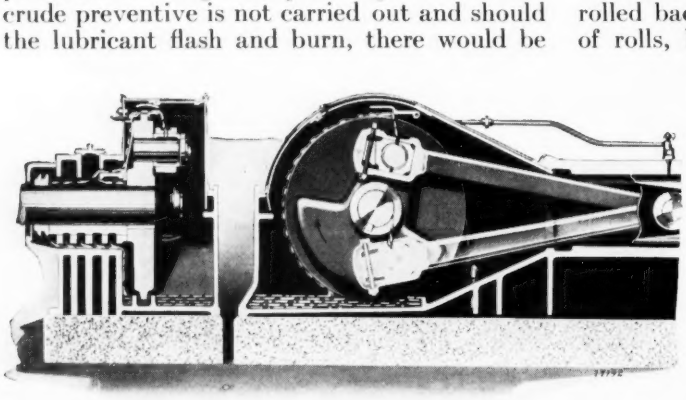
A number of types of lubricants may be used for this purpose. Some operators prefer to use beef tallow or a high melting point grease, which is placed in a cotton bag and stuffed between the mandrel and its respective socket in the side frame. Other plants use simply a lump of suet as the lubricant.

Experiments have proven, also, that a fairly high fire point (in the neighborhood of 440 degrees F.) liquid mineral lubricant having a viscosity of about 200 seconds Saybolt at 210 degrees F. will often be suitable for this purpose, the frequent custom being to use a felt pad of such a size as to fit over the entire exposed surface of the mandrel. This felt should be soaked in the oil for approximately 10 to 12 hours. Then it should be removed and allowed to drain of the surplus lubricant.

The frequency with which such felt should be soaked will, of course, depend upon the operating conditions. Once a week has proven satisfactory in certain plants. In event of operating rotary printing machines under excessively high pressures it may be even advisable to use steam cylinder oil which would have a viscosity of about 160 seconds Saybolt at 210 degrees F. and a fire point in the neighborhood of 600 degrees F.

However the lubricant is applied, there must be ample provision for the withdrawal of the lubricating medium promptly in event of the bearing becoming dangerously hot, before the

lubricant shall have a chance to take fire. This is usually done by simply pulling out the oil pad with a string or a pair of pliers. If this crude preventive is not carried out and should the lubricant flash and burn, there would be considerable probability of the fabric being charred or even burned before the blaze could be extinguished and the mandrel cooled down.



Courtesy of Ingersoll-Rand Co.

Fig. 7—Detailed view of the lubricating system on the crank end of an air compressor. Comparatively high pressures prevail on crank-shaft bearings, and positive lubrication is absolutely essential to prevent possibility of metal-to-metal contact or development of abnormal wear.

Rolling Mill Lubrication in the Steel Industry

The steel industry presents one of the most interesting examples of heavy duty machinery, operating frequently under temperature and dirt conditions which are decidedly conducive to impaired lubrication. In very many cases bearing ends and gears are exposed to flying slag, dust, dirt, scale or water. Pressures per square inch of bearing surface are high and means of lubrication may be comparatively crude.

And yet in the rolling mill, where such conditions may be especially prevalent, production must be continuous, stopping of a set of rolls, a table or shear being a serious matter, for it may mean a possible accumulation of ingots, bars or billets; loss of heats, and hold-ups in the delivery of ingots to the soaking pits. Especially will this be true where steel cannot be diverted to other rolls.

Rolling Mill Operation

In view of the potential problems involved, an insight into the scheme of operation of a typical rolling mill will be of interest. The blooming mill is the first and perhaps the heaviest duty machine involved in the rolling of steel. Its function is to reduce ingots of steel to slab or billet form.

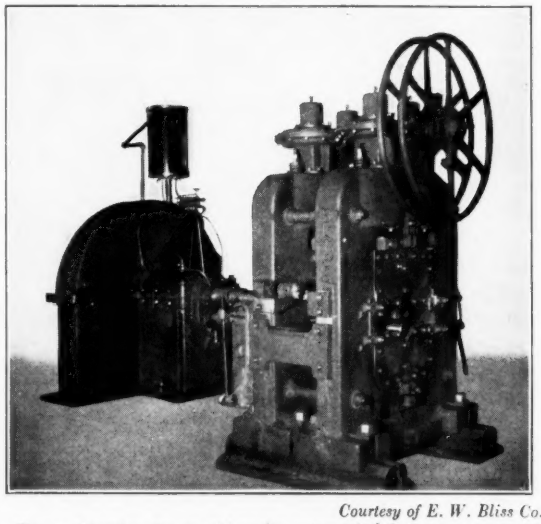
It consists essentially of two or three heavy cast steel rolls, gear-connected to a reversible steam engine or electric motor. The power rating of the driving element must be high, in extreme cases 35,000 to 42,000 horsepower being necessary.

In the 2-high (or two-roll) mill, the ingot is rolled backward and forward between one set of rolls, being squeezed down to the desired dimensions and also being greatly drawn out in length. The resultant product is called a slab or bloom according to the shape to which it is finally rolled.

While the usual blooming mill will consist of but two rolls, it is not at all uncommon for this machine to be built with three rolls. In this case, arrangement must be made whereby the steel can be passed back and forth through first the lower and then the upper set, without the necessity of changing their direction of rotation.

In the 3-high mill, as it is known, the ingot begins its passage by being run between the lower and middle rolls. It is then lifted automatically to the top level and passed back in the opposite direction between the top and middle rolls. At the end of its travel it is lowered for rolling again, in the original direction between the lower and middle rolls. The number of such alternate passes will depend entirely upon the extent to which the ingot is reduced at each rolling.

As shapes leave the blooming mill tables they are carried by other gear driven table rollers to suitable steam or hydraulic shears which crop the butt ends and cut the remaining sections into a number of shorter lengths for further rolling and reduction in one or more of the



Courtesy of E. W. Bliss Co.

Fig. 8—Showing the provisions for automatic lubrication as applied to a "cluster" mill designed for steel rolling purposes. Oiling leads and connections to the various wearing elements can be readily noted.

several other mills, according to the final shape and size of the resultant product. In other words, whatever the nature of the final product, the steel rolling mill will involve much the same equipment, and the process will constitute a series of rollings, croppings or shearings, coolings and usually reheatings.

In subsequent rolling the billet is directed by guides which direct it through the proper rolls. The construction of these guides is unusual and their type of service is severe for, of course, they come in direct contact with the hot metal.

Essentials of Lubrication

In rolling mill operation, gears, roll neck and journal bearings, steam cylinders and miscellaneous guide and shaft bearings constitute the usual frictional elements.

In the blooming mill, for example, the most important parts requiring efficient lubrication are the pinions and gears, roll necks and electric or hydraulic screw-downs for adjusting the rolls.

Gears and Pinions Must Function Effectively

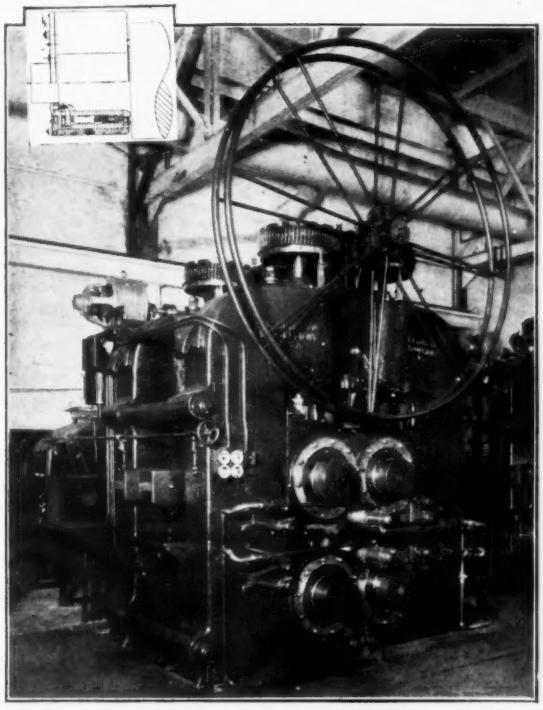
The pinions adjacent to the roll necks in the blooming mill are usually enclosed in an oil-tight casing, in which event they are run in a bath of specially prepared gear compound of high adhesive characteristics having a viscosity of about 2000 seconds Saybolt at 210 degrees F. On the other hand, in some installations these pinions may be only covered with shields which are not oil tight. Where this is done there is often no bottom to the gear case, therefore, bath lubrication is out of the question.

In consequence the lubricant must be able to stick tenaciously to the pinions over the periods which intervene between its application, withstand high tooth pressures, and maintain a sufficiently protective film. A viscosity of about 5000 seconds Saybolt at 210 degrees F. is often necessary here in order that the resultant lubricating film will be able to withstand the terrific pounding and hammering which occurs, especially whenever the mill is reversed.

In the blooming mill, as on many other rolls except in the plate and sheet mills, it is found necessary to run water constantly over the rolls and roll necks for the dual purpose of cooling and blowing off scale which may be formed as the ingots, bars or billets are broken down. Some mills, in addition, blow steam directly onto the ingot during its first pass through the rolls in order to more effectively remove the scale.

Water Conditions Require Compounded Lubricants

Such conditions, coupled with the extreme heat which is constantly encountered, places a most exacting requirement upon both the roll neck and gear lubricants. It has been determined that compounded products should be used inasmuch as straight mineral lubricants will not withstand the continued washing action of hot water. The usual procedure is to compound the gear lubricant with definite percentages of certain substances which will give the final product the desired adhesive properties.



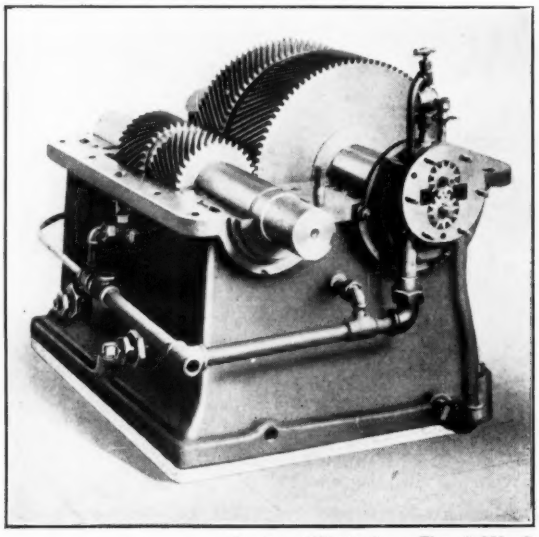
Courtesy of E. W. Bliss Co. and Rollway Bearing Co.

Fig. 9—Side view of the roll end of a "cluster" mill. Note that six rolls are involved, each main roller being held in position by a pair of larger guide rolls above and below. These rolls are equipped with "Rollway" roller bearings, to reduce friction, insure positive lubrication and counteract the reaction pressures which are developed. Note section of bearing above.

Rolling mill gearing, however, which does not come in contact with water can readily be lubricated with a straight mineral gear compound of a viscosity ranging from 1000 to 2000 seconds Saybolt, according to the temperature conditions, the manner of lubrication, and the pressure involved.

The rolls of continuous mills in turn are usually driven by herringbone pinions, and a set of relatively heavy gears. These pinions, in certain mills, are often so constructed as to make it necessary to lubricate the bearings with grease, and to maintain a continuous flow of cooling water over them. Naturally, this water will splash onto the pinions (where exposed), involving a condition and requiring a grade of lubricant as has been mentioned above in discussing the blooming mill. Where mills, however, are built with oil tight gear cases and

suitable shields, bath lubrication will be practicable. This, of course, is the admirable condition, for the utmost of protection is afforded both the lubricant and the gear teeth.



Courtesy of Westinghouse Elec. & Mfg. Co.

Fig. 10—Exposed view of a set of herringbone reduction gears showing lubricating piping and gear pump details. Tooth pressures can be markedly counteracted by effective lubrication.

Centralized Drives

In mills of the merchant type, several sets of rolls may frequently be dependent for their operation upon one set of pinions. It can be appreciated, therefore, that the lubrication of these latter is decidedly important. For example, if there is any sticking, catching or chattering in the pinions, or if they mesh improperly or the points ride, by the time motion has been transmitted to the end rolls any faulty operation will have become considerably exaggerated.

Lost motion, in fact, may develop to such an extent as to cause chattering, and markedly interfere with the finishing of the product. Where the final finishing rolls operate as individual units, this danger will, of course, be greatly reduced, although it should always be considered when selecting pinion lubricants. For this class of service the lubricant must be of relatively high viscosity and extremely adhesive, for water, heat and pressure conditions are often decidedly severe.

The bevel gears which drive the table rollers nearest to any type of rolling mill frequently operate exposed. They are, therefore, subject to water conditions, flying scale and the heat which radiates from the hot metal in its course through the plant. Here the gear lubricant is difficult to apply in the first place, and furthermore, after it has been applied there is every possibility of its functioning ineffectively. Centrifugal force will tend to throw it off, especially where it has suffered any extensive reduction in viscosity due to over-heating, or where pressure has squeezed it to the sides of the teeth.

The washing action of the water which splashes over such gears is also a detriment. In addition, excessive contamination by solid foreign matter can hardly be avoided, unless precaution is taken to effectively guard such gears.

Ultimate protection can only be attained by frequent applications of a lubricant which has been so refined as to withstand these detrimental conditions. Usually the same product as employed on blooming mill gears must be used, the viscosity ranging from 1000 to 2000 seconds Saybolt at 210 degrees F., according to temperature and pressure conditions. It should be applied by pouring onto the teeth at the point of mesh while the gears are running inward.

The frequency of application will, of course, depend upon the amount of steel rolled through the mill and the intensity of operation. In general, over-lubrication leads but to waste, for a uniform film which covers the entire wearing surfaces is all that is necessary for their adequate protection. The application of any excess lubricant will simply mean that it will be squeezed out and probably thrown from the teeth in a short time.

Plate Mill Service

Plate mills present an additional detrimental condition due to the quantities of salt which are thrown on the plates during the process of rolling, and also the fact that the red hot plates pass directly over the bearings and gears of the table rollers.

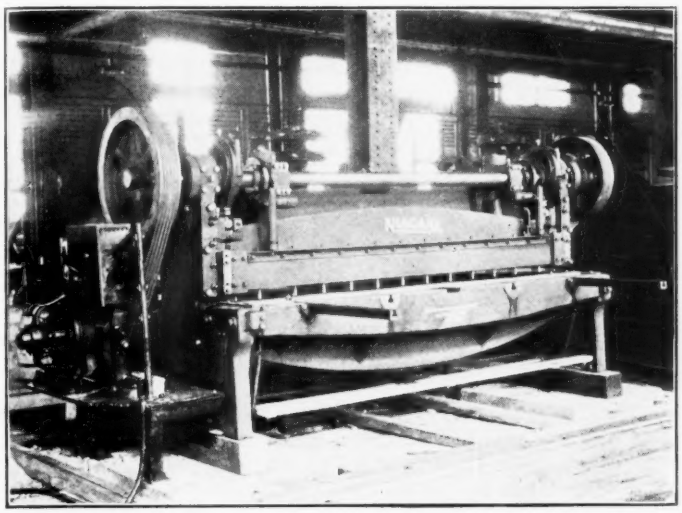
The purpose of salting is to remove the scale. Oftentimes water is also sprayed on the rolls in addition. These factors, coupled with flying scale and dust which is driven with considerable force when the hot gases explode, tend to destroy any lubricant used on the roll necks, table roller bearings and gears.

Types of mineral gear compounds as specified above have been found to withstand these detrimental elements quite satisfactorily, provided they are applied at frequent intervals and in sufficient quantities.

The Screw-Down

As its name implies, this consists of two long screws driven by electric or hydraulic power; its purpose is to raise or lower the rolls as necessary. The screw-down is subject to considerable pressure, as a rule, and therefore it requires careful lubrication. The screws should be lubricated periodically with a fairly heavy

grade of straight mineral, steam refined cylinder oil of a viscosity sufficient to withstand the high pressures which are involved.



Courtesy of Allis-Chalmers Mfg. Co.

Fig. 11—Front view of a Niagara punch press. Note individual oil cups for bearing lubrication and the Texrope drive at left.

DIRECT PRESSURE MACHINERY

In the case of equipment designed for the direct application of pressure, such as the metal press, hammer or stamping machine, for example, operation is "intermittent." In other words, motion is, as a rule, reciprocating, pressure being exerted on the down stroke of the stamp or die.

The Metal Press

Where the metal press is concerned high reactionary pressures will be exerted on the main bearings and the gear drives. In many cases under working conditions such pressures will run from four to five thousand pounds per square inch.

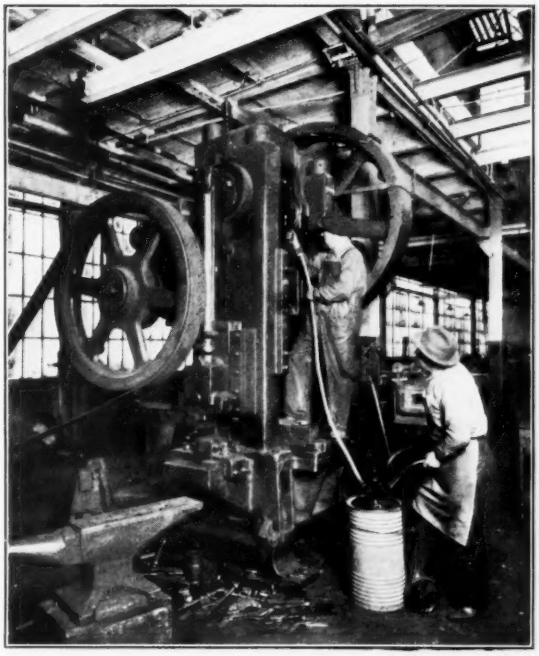
As a matter of explanation it is well to repeat that reactionary pressure may be regarded as the pressure which reacts back through the working parts as the press, slide, ram or other particular metal forming element performs its function. As a general rule, the period of maximum intensity will be comparatively brief.

To an extent this will permit of renewed lubrication of the bearing elements, if adequate means of automatic or forced lubrication is available. In consequence the effects of squeezing out of the lubricant may not be as marked, as might occur where continuously high pressures are encountered as in the case of machines involving rolling motion, such as the calender or textile printing machine.

Normally, however, intermittent reactionary pressure may be considerably higher per square inch of bearing surface. So the means of lubrication and the lubricants employed must always be of adequate body and adhesiveness to resist being entirely squeezed out, otherwise, at some point of the stroke, actual metal-to-metal contact may occur.

Of course, this latter will be only momentary, provided the lubricating system is capable of renewing the film prior to the next power stroke; in other words, provided that continuity of oil supply is maintained to insure delivery of adequate lubricant to replace that which may be squeezed out. This is especially important where but a small quantity of lubricant is being delivered to the bearings.

It must be remembered that even if momentary metallic contact between either bearings or gear teeth is allowed to occur repeatedly for a sufficient length of time, wear will ultimately develop which may markedly affect machine operation and the accuracy of production. Enclosed construction of wearing elements and the operation of these parts in a bath of lubri-



Courtesy of The Safety-Lift Co.

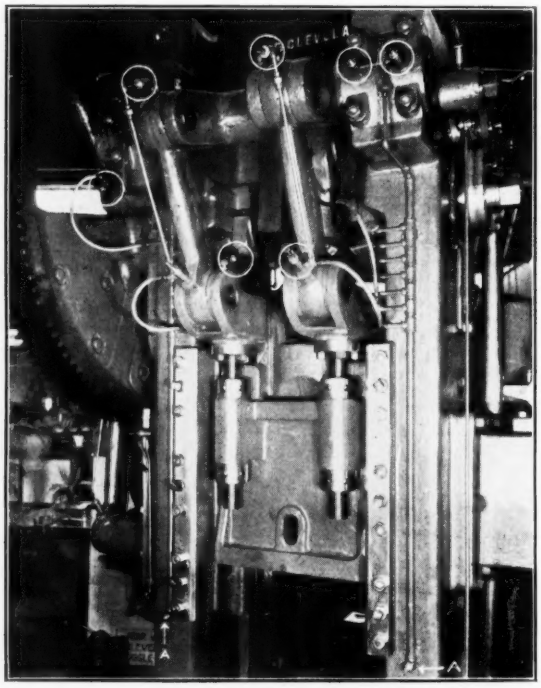
Fig. 12—Applying grease lubrication to a press. Here is an instance of counteracting high bearing pressures by means of lubricant applied under high pressure.

cant of adequate viscosity will correct this condition on certain types of pressing or stamping machinery, especially where there is suffi-

cient bearing area and where oil grooves are properly designed.

Means of Lubrication

It is practicable to use either oil or grease for the lubrication of many of the wearing elements



Courtesy of Industrial Oil Equipment Co.

Fig. 13—A pressure lubrication system applied to a Cleveland press. At "A" are shown points for grease application, subsequent delivery being through piping as shown to the spring actuated pressure grease fittings as indicated by circles.

of metal forming machinery. The ultimate factor will involve the type of lubricating equipment provided, the operating conditions such as speed and bearing pressures, and details of construction, such as manner of grooving.

By virtue of the size, number of bearings and bulky nature of such machines it has been deemed advisable in many cases to provide for some form of positive, automatic lubrication. Greater convenience should thereby result, with frequently marked savings in labor due to reduction in the amount of attention necessary.

Where grease is to be used, especially on larger machines, it is important to remember that the employment of lengthy piping layouts may lead to clogging in certain parts, especially where bends or other fittings may be numerous. This has even been found by some to cause inequalities in delivery; in other words, certain bearings being "starved" while others may be over-lubricated. With a carefully designed installation, however, and the exercising of good judgment in the selection of greases which will show the least tendency to gum, carbonize or separate, the possibility of subsequent trouble should be markedly reduced.

Means or equipment for automatic lubrication will be usually confined to the bearings of the average press. Where gears are involved for driving or speed reduction purposes they will frequently be but partly guarded or encased. When speeds are not excessive bath lubrication may be possible, using a comparatively fluid gear lubricant. Under higher speed conditions, however, or where the lower part of the casing may not be sufficiently oil-tight, a more inert product may be advisable.

A high degree of adhesiveness is essential under such conditions; this is a characteristic of those straight mineral lubricants of from 1000 to 2000 seconds Saybolt viscosity at 210 degrees F. which have proven so particularly adaptable to gear service of this nature. Normally, such lubricants will be applied by hand, but they are so enduring in service and so resistant to the squeezing-out effects of high tooth pressures, and the throwing-off effects of centrifugal force that re-lubrication is only essential at infrequent intervals.

THRUST BEARING LUBRICATION

Of the various machinery involving comparatively high operating pressures, the thrust bearing is perhaps the most unique, inasmuch as it is a pressure absorbing device. In general, it will be used as a connecting media between shafting for the purpose of taking up thrust pressures exerted by the adjoining machinery on one side to keep these pressures from reacting upon the mechanism on the other.

There are two essential types of thrust bearings in use, viz.:

Multi-Collar Types

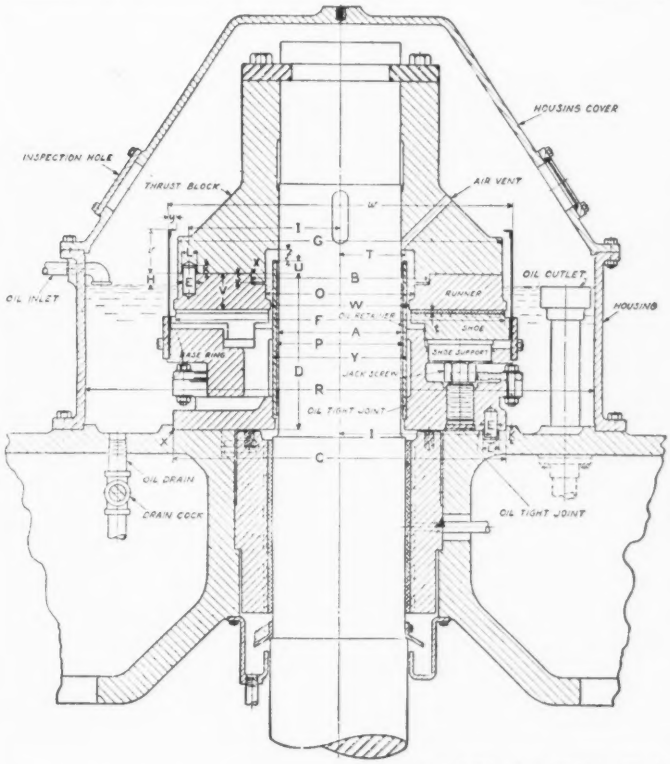
Those involving a thrust shaft equipped with a number of rings or collars. Normally such designs will be known as plain thrust bearings, or

Those of the horseshoe collar type, which consist of a length of shafting built with a series of channels into which are fitted suitable horse-shoe collars, and

Single Collar Types

Which include those bearings of the Kingsbury, G. E. Spring, Gibbs and Michell types, used extensively in hydro-electric, turbo-generating and marine installations. All use but a single collar. Opposed to this collar is a bearing member designed to produce oil films for separating the surfaces while running. Different constructions are used in the several types mentioned. In the Kingsbury bearing, for example, a plain collar forms one bearing

member, the other being formed by pivoted segments. These latter are free to tilt both radially and tangentially by virtue of their manner of construction and support.



Courtesy of Kingsbury Machine Works.

Fig. 14—Mounting for an adjustable thrust bearing and self-aligning guide bearing, arranged for an oil circulating system.

According to Professor Kingsbury, during rotation these faces will be completely separated by an oil film, which will automatically change its shape and thickness to conform to the load imposed, the speed of operation, and the relative fluidity or viscosity of the oil.

The load on the modern thrust bearing, whether vertical or horizontal, is uniformly distributed; actual metal-to-metal contact between the fixed and sliding elements is prevented by films of oil which adhere to the bearing surfaces and separate them during rotation. Operating efficiency will hinge not only upon the bearing design, but also upon the ability of the oil to maintain a lubricating film of adequate thickness.

Vertical Type Bearings

In the vertical thrust bearing best results will be attained by operating the bearing faces submerged in oil.

A certain amount of heat will always be developed, and in the properly designed bearing, as the heated oil from the films passes back to the main body of oil, this heat will be given up. Where water cooling is employed, as is customary under high speed conditions, or where oil is circulated through the system under pressure, this heat is removed from the bath and the temperature kept constant.

Selection of Oil

For average conditions, i.e., with pressures below 400 pounds per square inch, a highly refined non-emulsifying straight mineral oil having a viscosity of from 180 to 200 seconds Saybolt at 100 degrees F. will normally meet operating requirements. The bearing manufacturer should always be consulted in regard to the viscosity of oil to use, however, especially if he has made no specific viscosity recommendations at the time of installation, for the method of oil cooling employed must always be considered.

Manufacturers' recommendations vary with the above conditions, from viscosities of 150 to 700, or even higher, at 100 degrees F. As a rule, where oil circulation is provided for, lower viscosities will be suitable than where the system is water cooled; whereas, when air cooling is employed the viscosity should be higher. The above will hold true for average stationary machines. In marine service somewhat heavier oils are generally used.

Thrust oil properly chosen and applied will last for a considerable period if no objectionable features are allowed to develop in the lubricating system.

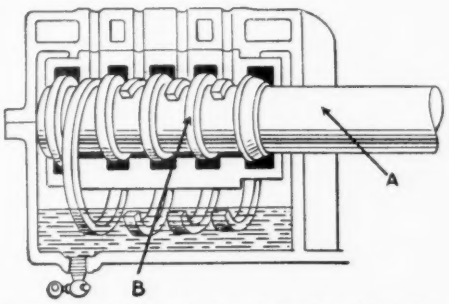


Fig. 15—A plain collar type horizontal thrust bearing equipped with ring oilers. The collars "B" fixed to shaft "A" counteract any horizontal thrust in company with a film of lubricating oil at the points of contact in the thrust block recesses.

Higher Pressures Require Heavier Oil

In certain industrial installations, however, thrust pressures may frequently exceed 1000 pounds per square inch. An example of this would be involved in the plate glass grinding

and polishing machine. For such bearings an oil of considerably heavier body must be used. Straight mineral steam cylinder oils have been proven adaptable to such service. Normally their viscosity should range from 130 to 160 seconds Saybolt at 210 degrees F.

Steady Bearings

Where a steady bearing above the thrust is desirable, both can be effectively lubricated in an automatic manner. Frequently this is accomplished by means of a suitable oil pump within the mounting itself.

Another way of lubricating a steady bearing above a thrust bearing where moderate speeds are involved is to run the lower end of the steady bearing sleeves in a bath of oil, making use of a helical groove in the revolving journal to carry the oil to the top of the steady bearing in order to lubricate its whole length.

Cooling

Cooling, of course, is important. Where speeds are not excessive, air-cooling is practicable; water cooling is, however, preferred under high speed conditions. The cooling may be accomplished at the bearing, or a series of bearings in one or more machines may be served by a circulating system in which there is an adequate cooling unit.

It is interesting to note that where air-cooling of the oil for a high speed thrust or steady bearing is desirable, the oil can be cooled if circulated through a coil placed in the path of moving air. The pump may be gear-driven by the thrust block which is formed by the steady bearing sleeve. Oil from the bath is drawn into the pump and forced down through the air-cooled coil which is bolted to the bottom of the housing. The coil discharges its oil at the top of the mounting, where it supplies the steady bearing. From there it flows by gravity through ample passages to the reservoir again. Such an arrangement, however, if used in a machine which runs first in one direction and then in the other, would require check valves in the pump to render it reversible.

In such a system a pure mineral oil should always be used, inasmuch as a compounded oil will have a tendency to emulsify in contact with water.

Horizontal Installations

Lubrication of the average horizontal thrust bearing is important, inasmuch as overheating of the rings, collars or shoes due to lack of oil will rapidly cause scoring of the bearing metal, with the necessity of serious cessation of operation for repairs. Force feed or copious bath lubrication is generally employed on heavy duty horizontal bearings such as the segment or shoe type of bearing mentioned above, in order to insure a uniform film of lubricant at all times. Cooling is just as essential for a horizontal as for a vertical bearing.

Oil Level

A thrust bearing housing, whether horizontal or vertical, should be kept filled with clean oil to a level recommended by the builder. Leaks should be guarded against inasmuch as excessive lowering of the oil level would result in overheating. Dirt, grit and other foreign matter are serious factors in the lubricating system of a thrust bearing, and may involve scouring and wearing down of the bearing faces, and overheating.

Multi-Collar Bearings

Wick feed supplemented by bath lubrication is generally found on horseshoe type and plain thrust bearings. Considerable care must be exercised constantly in lubricating thrust bearings of these latter types due to the frequent practice of running with an emulsion of water and oil.

During continued operation this emulsion will tend to become heavier and heavier until the oil ways may ultimately become so clogged that relatively the only lubrication possible will be furnished by the wick feeds. Thus overheating will be probable. Therefore, the engineer should watch the nature of this emulsion carefully, and as soon as it shows a tendency to thicken abnormally, the bearing should be thoroughly cleaned out and the oil renewed.

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